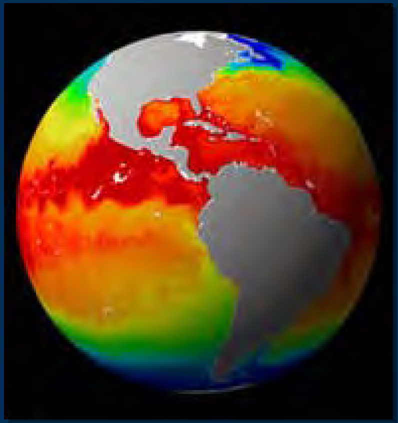
Sea-level Rise Science and Decision Making in an Uncertain Future



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Report Documentation Page

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14. ABSTRACT

Assessing the potential vulnerability of the coastal zone to sea-level rise (SLR) requires integrating a variety of physical, biological, and social factors. These include landscape habitat, and resource changes, as well as the ability of society and its institutions to adapt. The range of physical and biological responses associated with SLR is poorly understood at some of the critical time and space scales required for decision making. Although the general nature of the coastal changes that can occur in response to SLR is widely recognized, predicting what changes may occur in response to a specific rise in sea level at a particular point in time is difficult. Similarly, the cumulative impacts of physical and biological change on infrastructure natural resources, and the quantity and quality of coastal habitats are not well understood. Limitations in the ability to quantitatively predict outcomes at local, regional, and national scales affect whether, when, and how some decisions will be made. Thus, decision makers require tools to understand and anticipate the magnitude and likelihood of future SLR impacts, as well as evaluate the consequences of different actions (or inaction). Engaging both scientists and decision makers in the development of decision tools informs science activities that will result in more useful predictions and products for management.

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KEYNOTE ADDRESS
SEA-LEVEL RISE SCIENCE AND DECISION MAKING IN AN UNCERTAIN FUTURE

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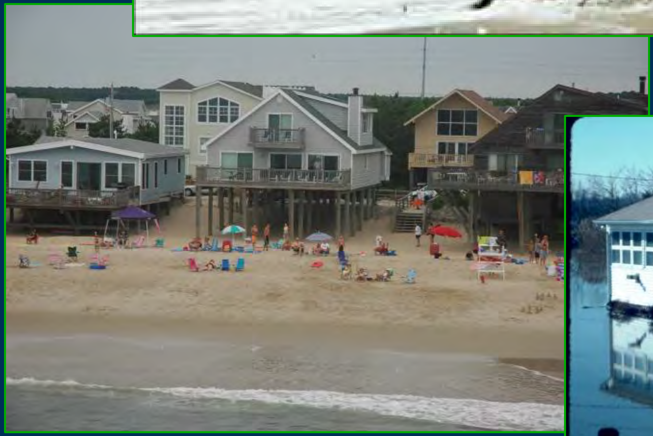
Assessing the potential vulnerability of the coastal zone to sea-level rise (SLR) requires integrating a variety of physical, biological, and social factors. These include landscape, habitat, and resource changes, as well as the ability of society and its institutions to adapt. The range of physical and biological responses associated with SLR is poorly understood at some of the critical time and space scales required for decision making. Although the general nature of the coastal changes that can occur in response to SLR is widely recognized, predicting what changes may occur in response to a specific rise in sea level at a particular point in time is difficult. Similarly, the cumulative impacts of physical and biological change on infrastructure, natural resources, and the quantity and quality of coastal habitats are not well understood. Limitations in the ability to quantitatively predict outcomes at local, regional, and national scales affect whether, when, and how some decisions will be made. Thus, decision makers require tools to understand and anticipate the magnitude and likelihood of future SLR impacts, as well as evaluate the consequences of different actions (or inaction). Engaging both scientists and decision makers in the development of decision tools informs science activities that will result in more useful predictions and products for management.

Outline

- Scientific and management dimensions of sea-level change
- Results and implications of a recent USGCRP sea-level rise assessment
- Providing science-based decision support in an uncertain future

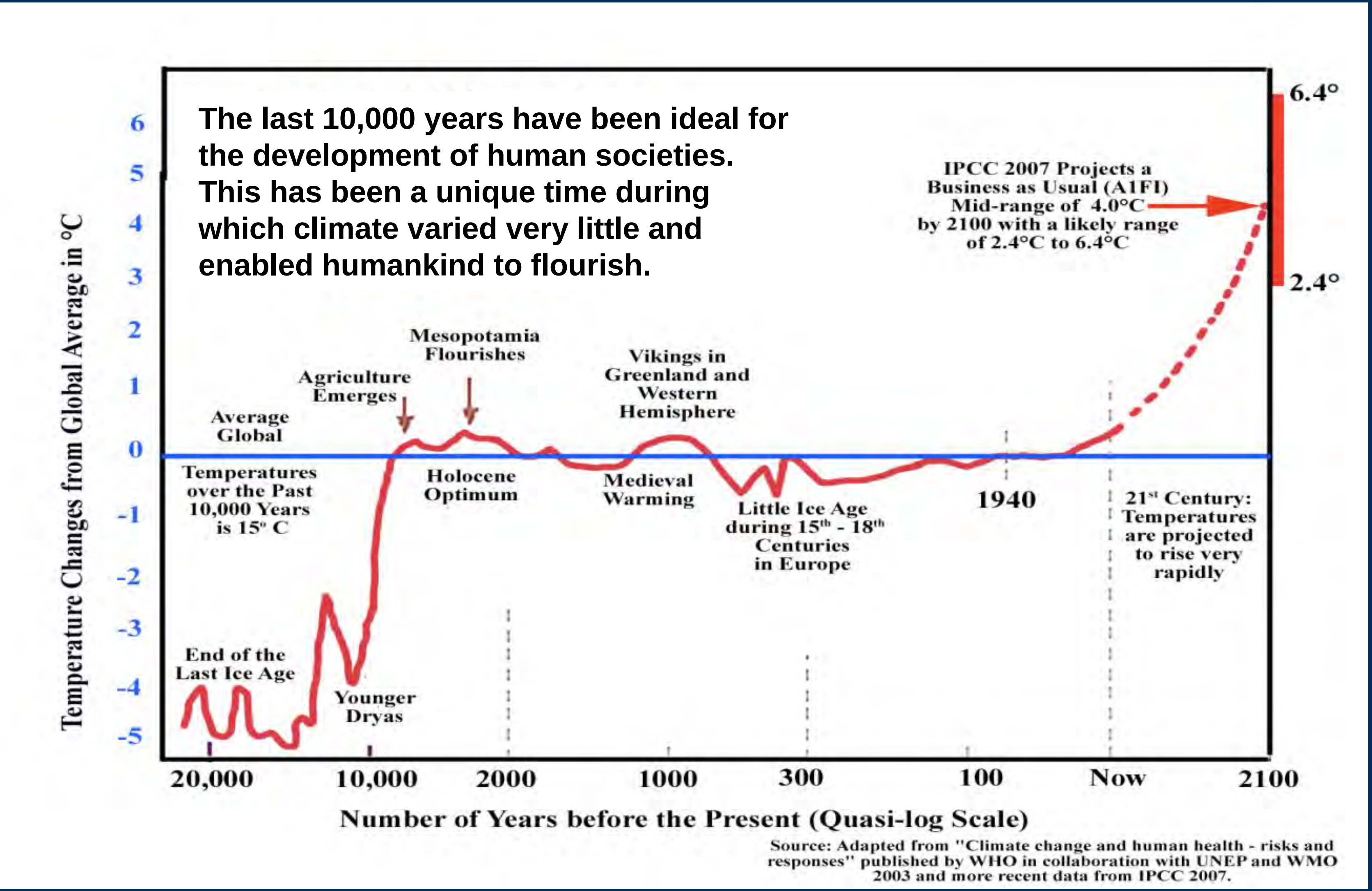
We need better science* to prepare our local responses to climate change, especially in our coastal areas.
(David Carter, Delaware Coastal Management)



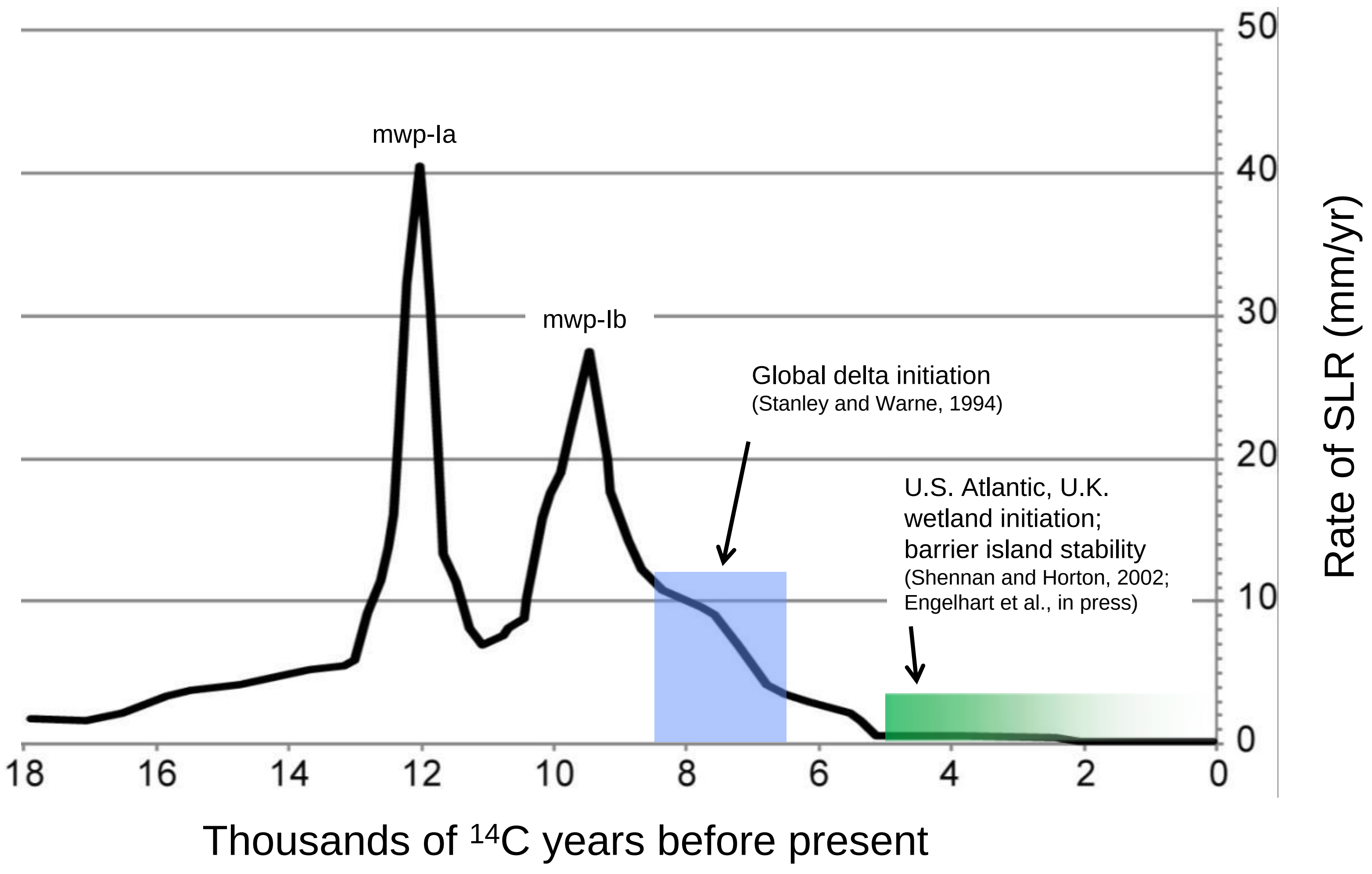


*science = better understanding of processes + better situation awareness

Past, Current and Projected Global Temperature

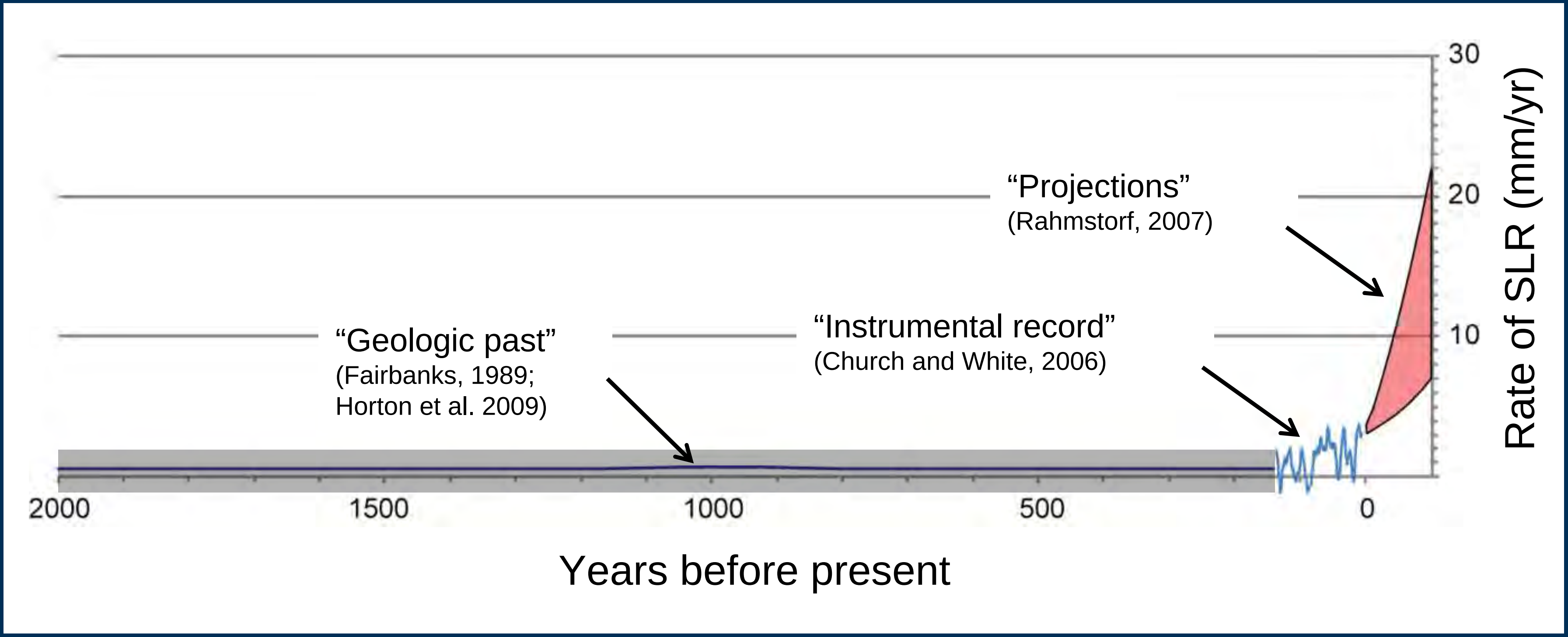


Sea-level rise rates since the Last Glacial Maximum

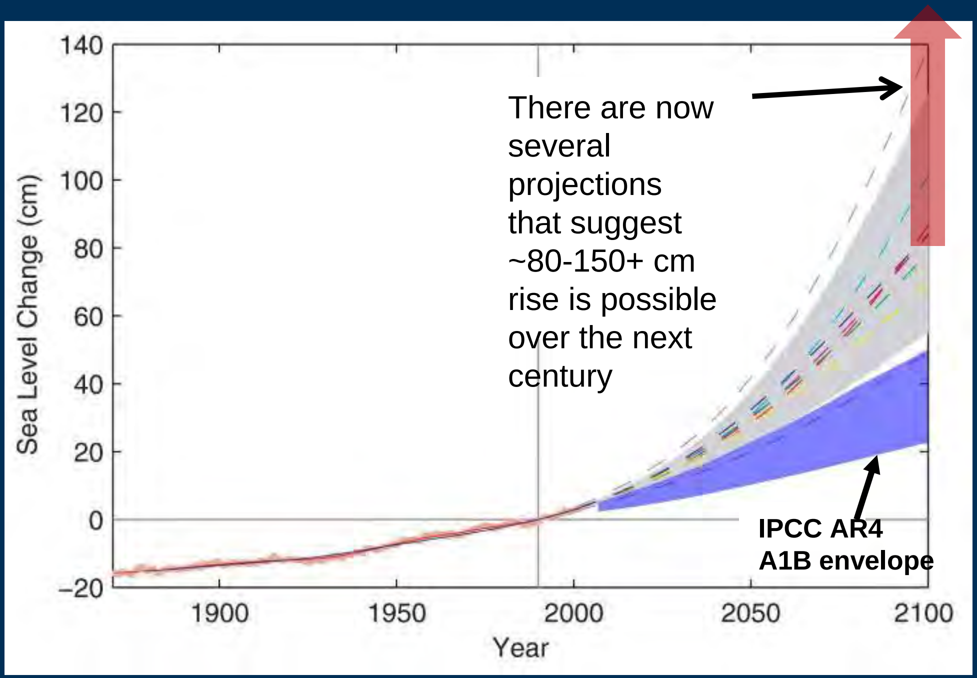


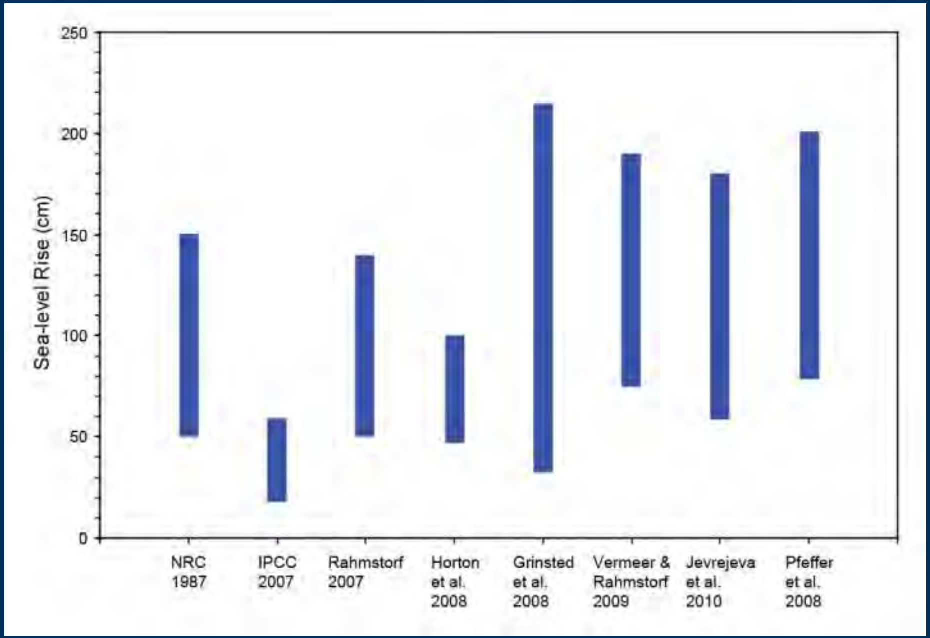
(SLR rate based on Fairbanks, 1989)

Past, present, and potential future rates of sea-level rise



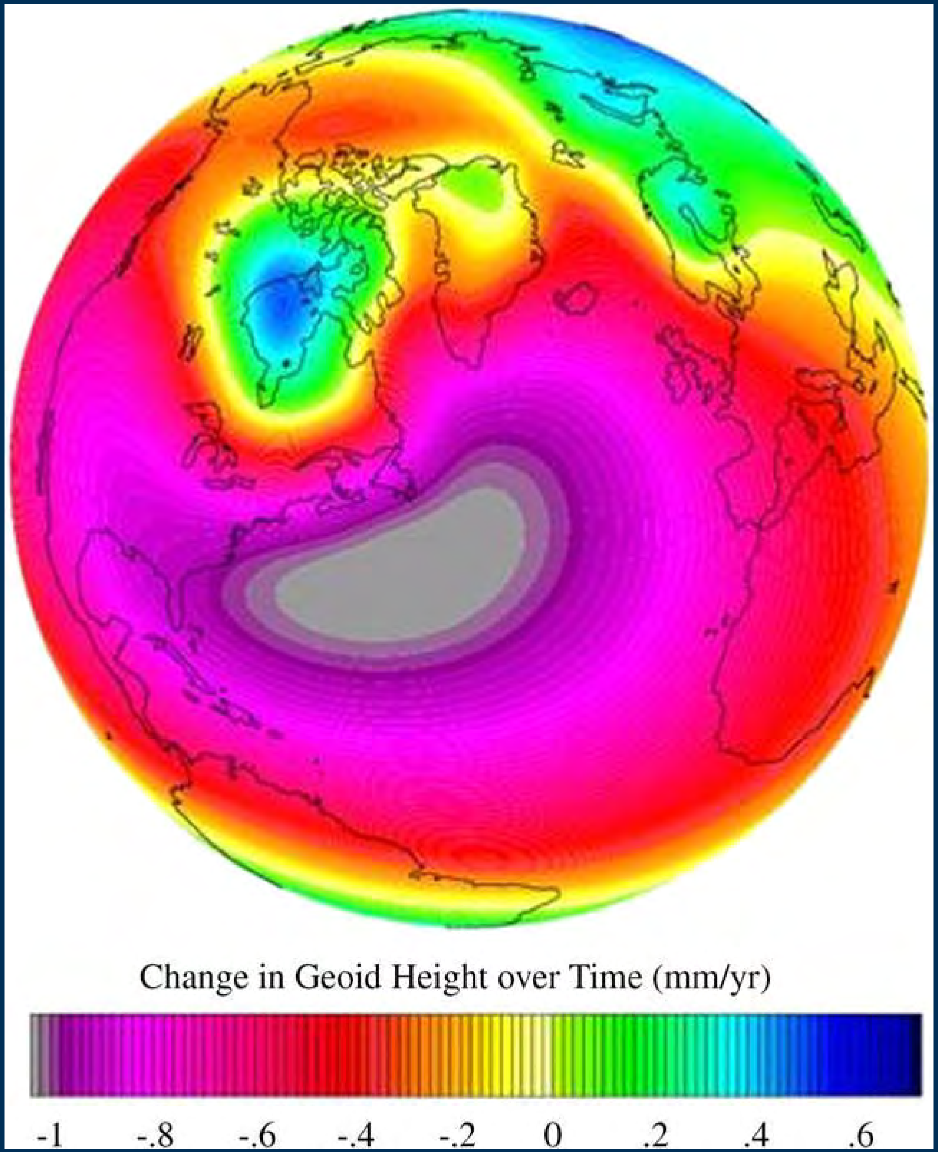
Historic and Projected Sea-level Rise





Issue: Global variability in SLR

Earth is still undergoing isostatic adjustment from deglaciation

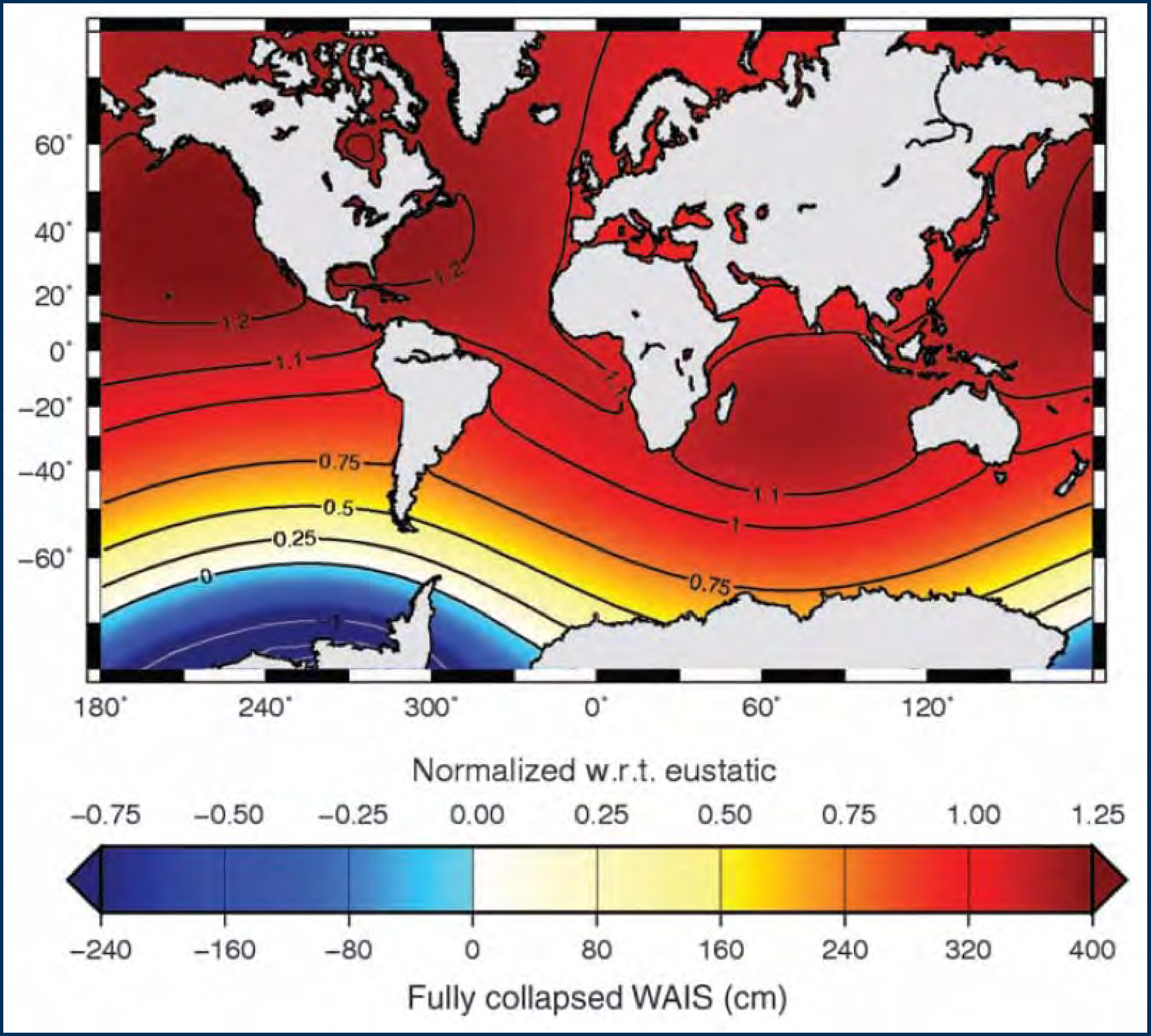


(Horton et al., 2009)

Issue: Global variability in SLR

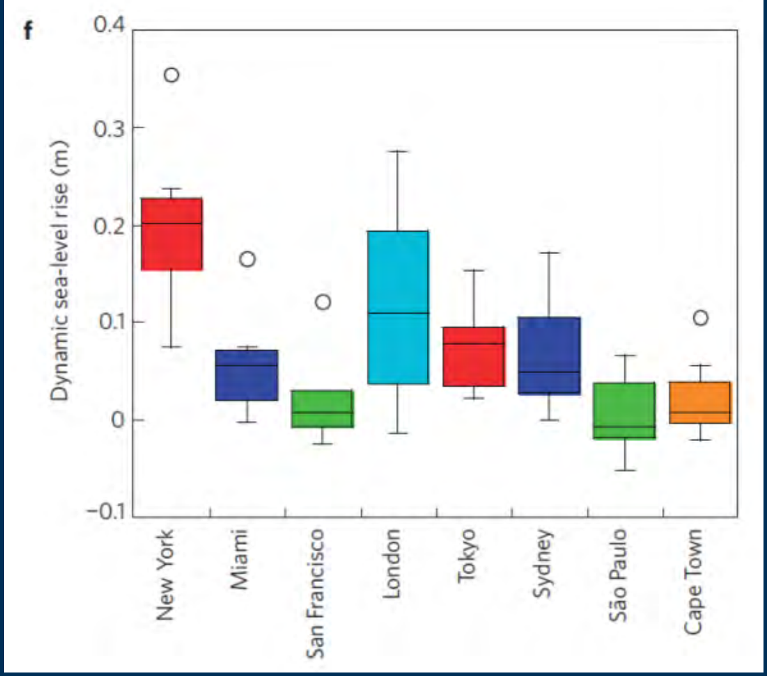
Loss of the West Antarctic Ice Sheet can cause up to 25% more SLR on the U.S. coast.

Not likely to happen during the 21st century.

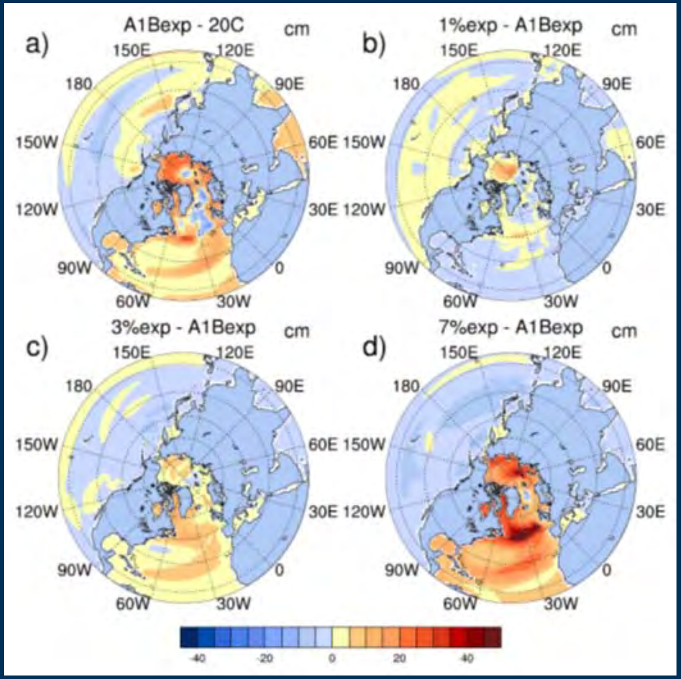


(Bamber et al., 2009)

Issue: Regional variability in SLR



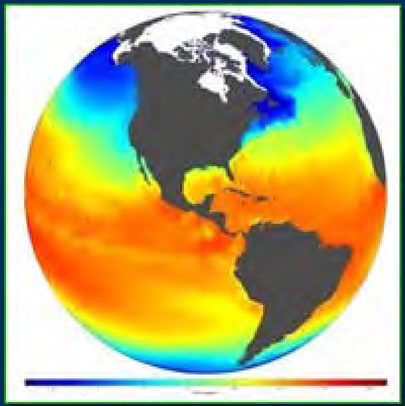
(Yin et al., 2009)



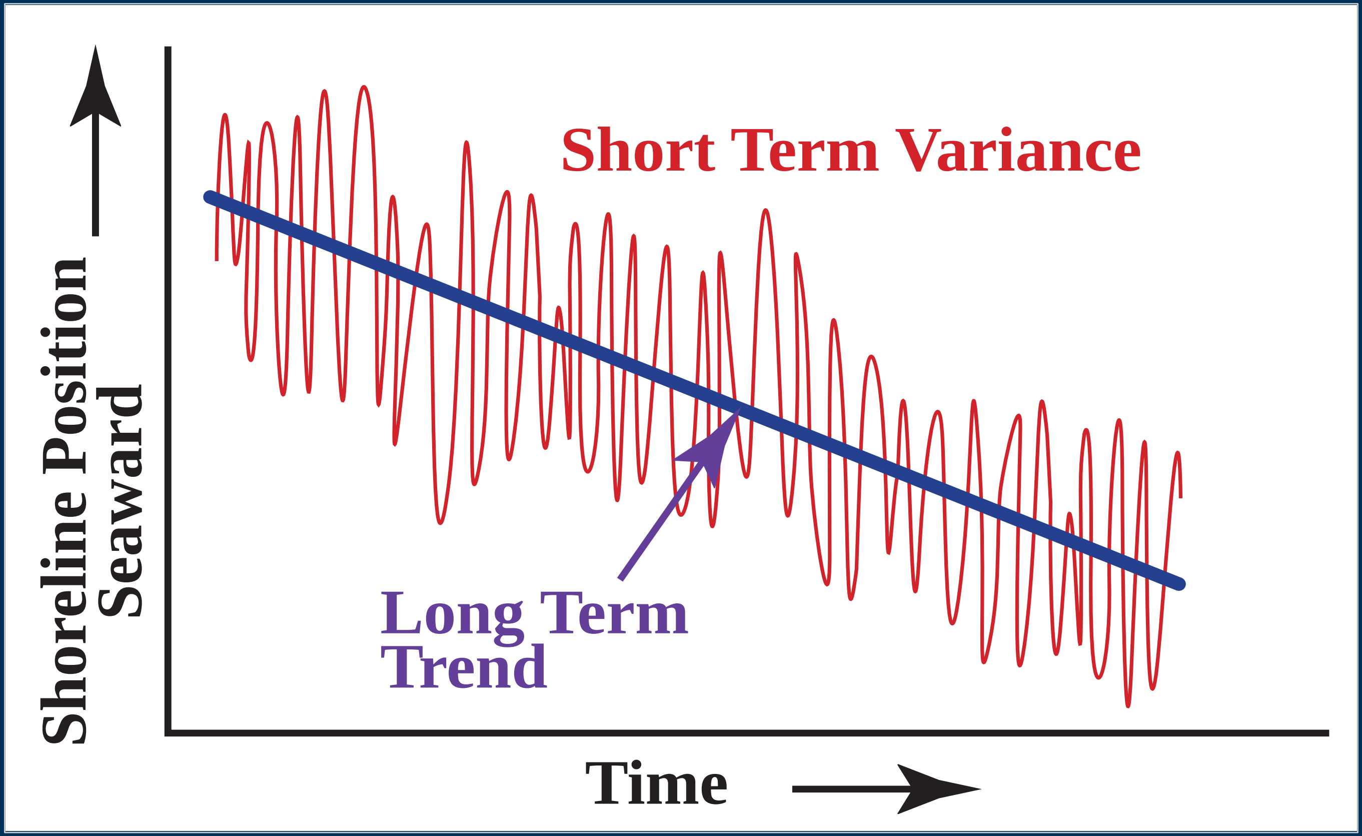
(Hu et al., 2009)

Regional changes in circulation and ocean warming can increase sea level by tens of centimeters, for example in the northeastern U.S. (north of Cape Hatteras).

Importance of Spatial Scale



Importance of Temporal Scale



Short-term Variance

(hours to decade)

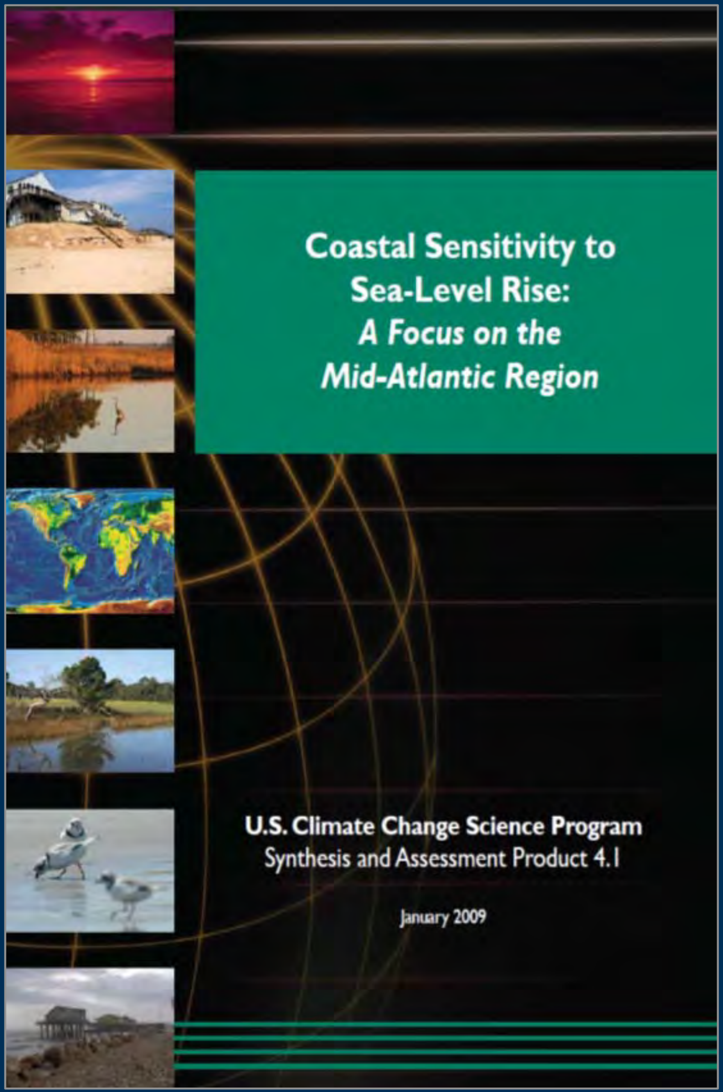
Storm impact/recovery
Annual cycles
El Niño

Long-term Trend

(decades to centuries)

Sediment deficit or surplus
Sea-level rise

Coastal Sensitivity to Sea-Level Rise:
A Focus on the Mid-Atlantic Region

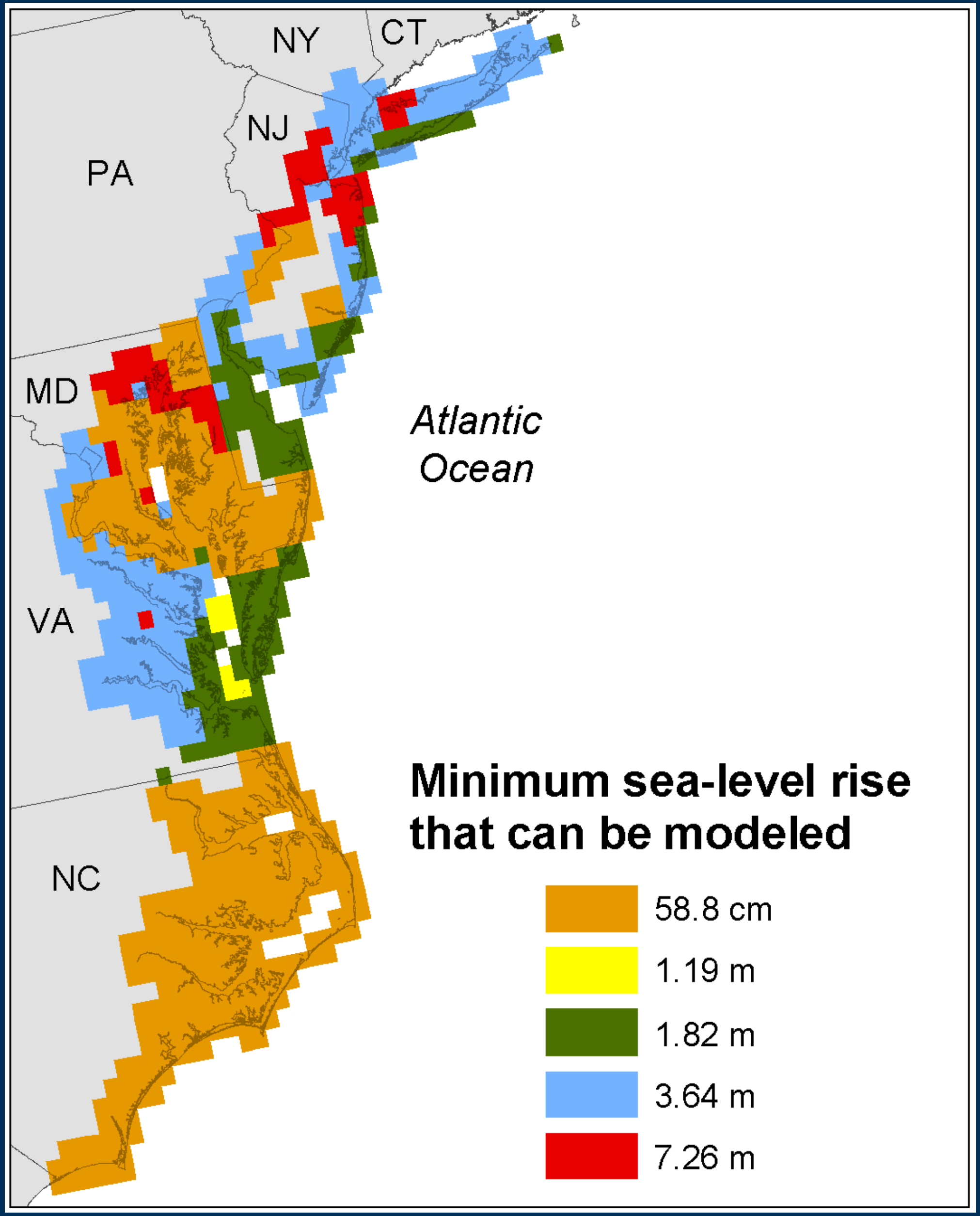


U.S. Climate Change Science Program

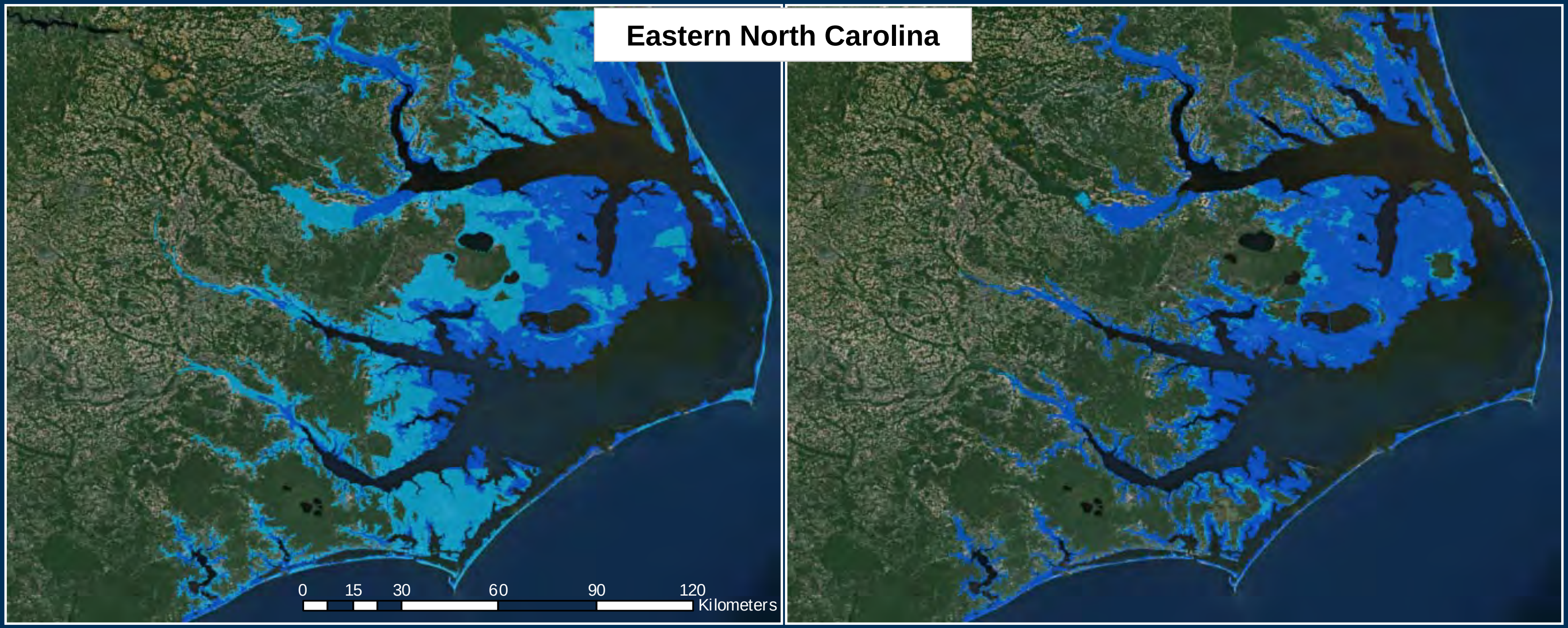
Synthesis and Assessment Product 4.1

Coastal Elevation Data

- Elevation is a critical factor in assessing potential impacts (specifically, inundation)
- Current elevation data do not provide the degree of confidence needed for quantitative assessments for local decision making
- Collection of high-quality elevation data (lidar) would be valuable

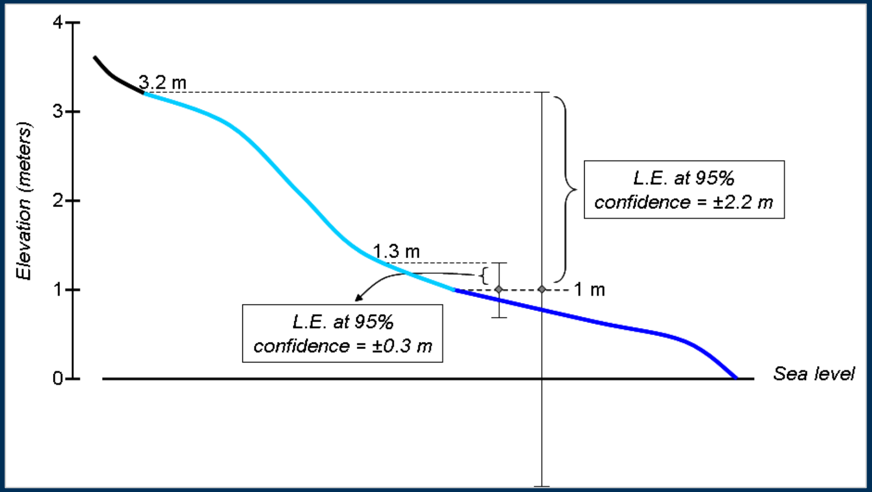


(Gesch et al., 2009)



Elevation source: 30-m DEM

Elevation source: 3-m lidar data



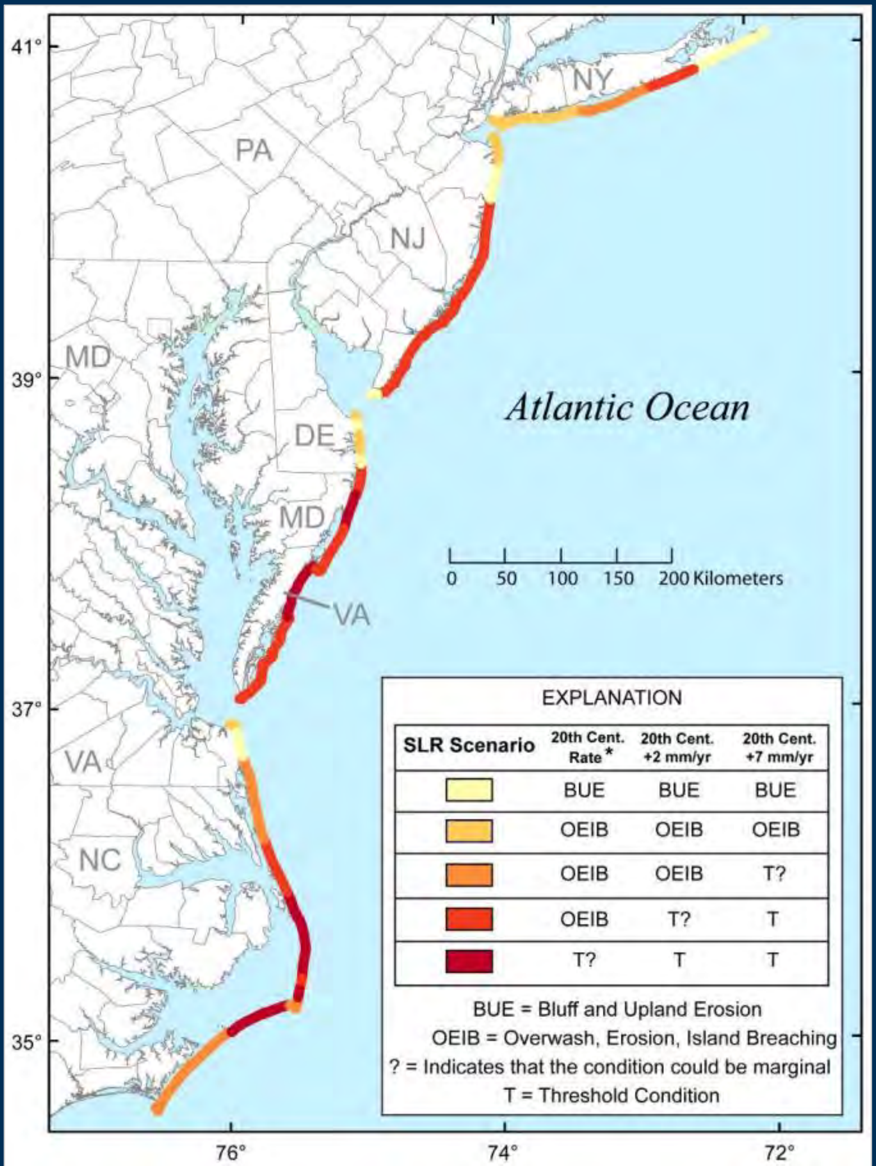
Dark blue **Land ≤ 1 meter elevation**

Light blue **Area of uncertainty associated with 1 meter elevation**

- High quality elevation data reduce uncertainty of potentially inundated areas

(Gesch et al., 2009)

Mid-Atlantic Assessment of Potential Dynamic Coastal Responses to Sea-level Rise



(Gutierrez et al., 2009)

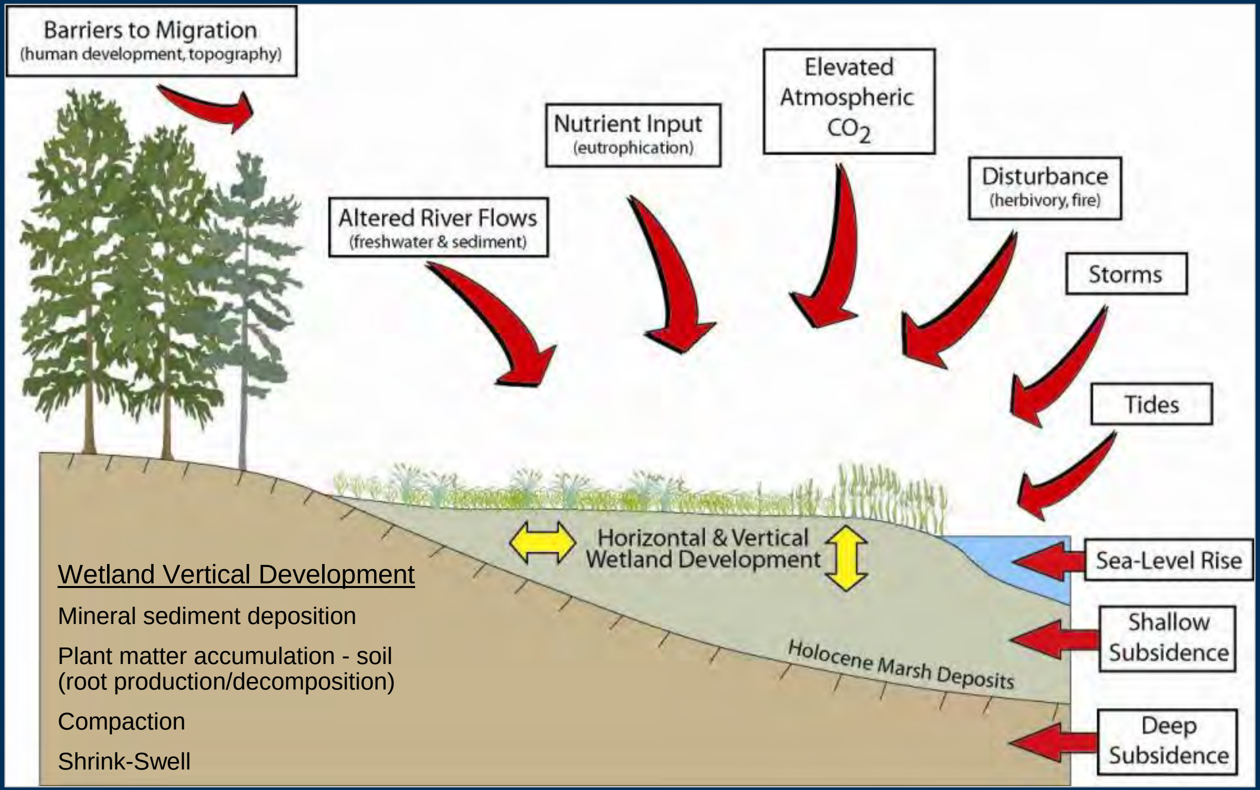
Bluff erosion

Overwash

Island Breaching

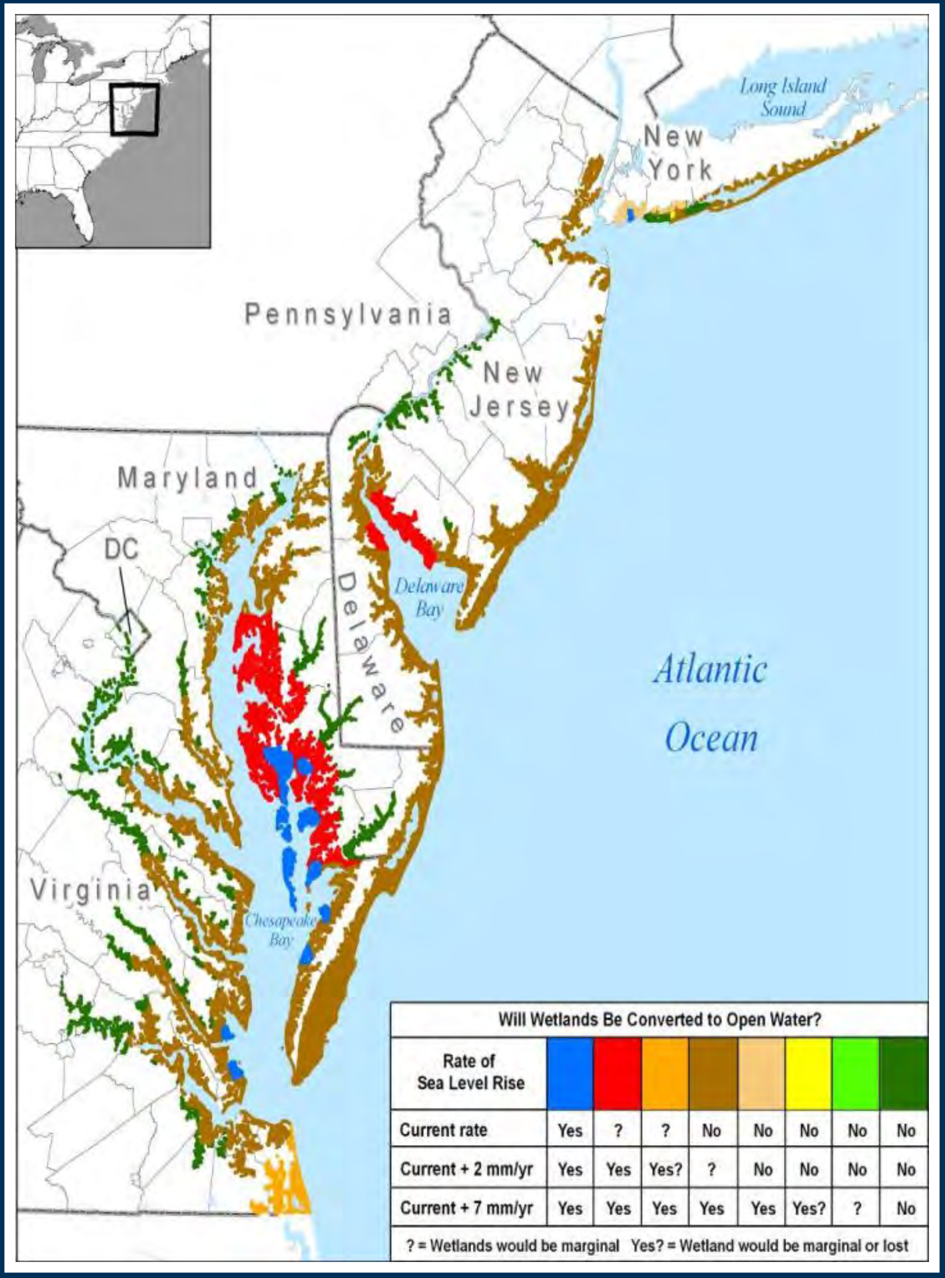
Threshold Crossing

Coastal Wetlands Respond Dynamically to Environmental Change



(Cahoon et al., 2009)

Mid-Atlantic Wetlands Assessment

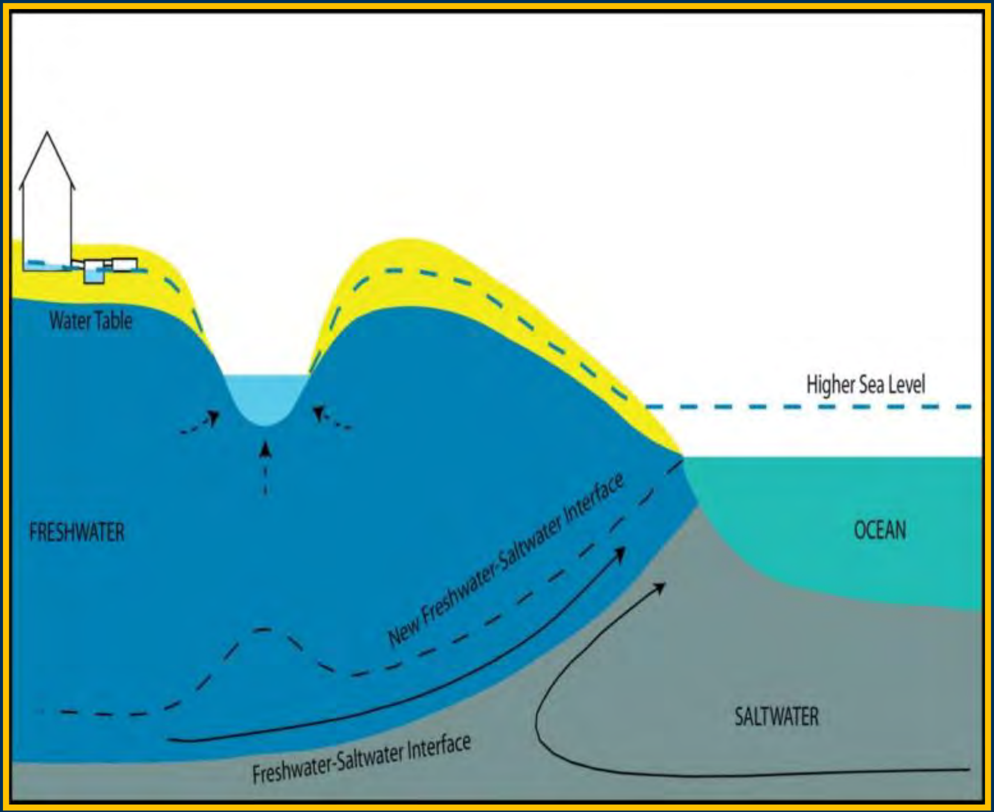


Will Wetlands Be Converted to Open Water?								
Rate of Sea Level Rise								
Current rate	Yes	?	?	No	No	No	No	No
Current + 2 mm/yr	Yes	Yes	Yes?	?	No	No	No	No
Current + 7 mm/yr	Yes	Yes	Yes	Yes	Yes	Yes?	?	No

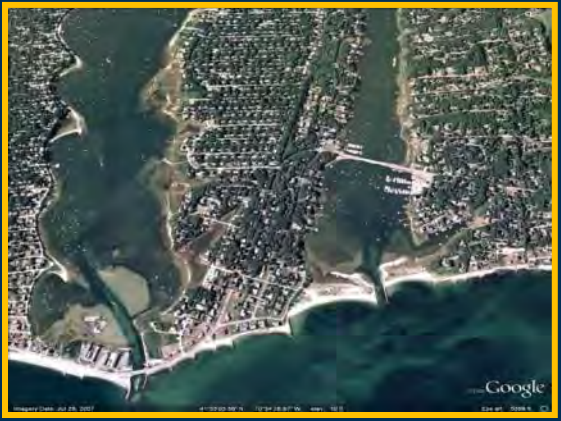
? = Wetlands would be marginal Yes? = Wetland would be marginal or lost

(Cahoon et al., 2009)

Sea-Level Rise Impacts on Groundwater Systems



Water quality reduction

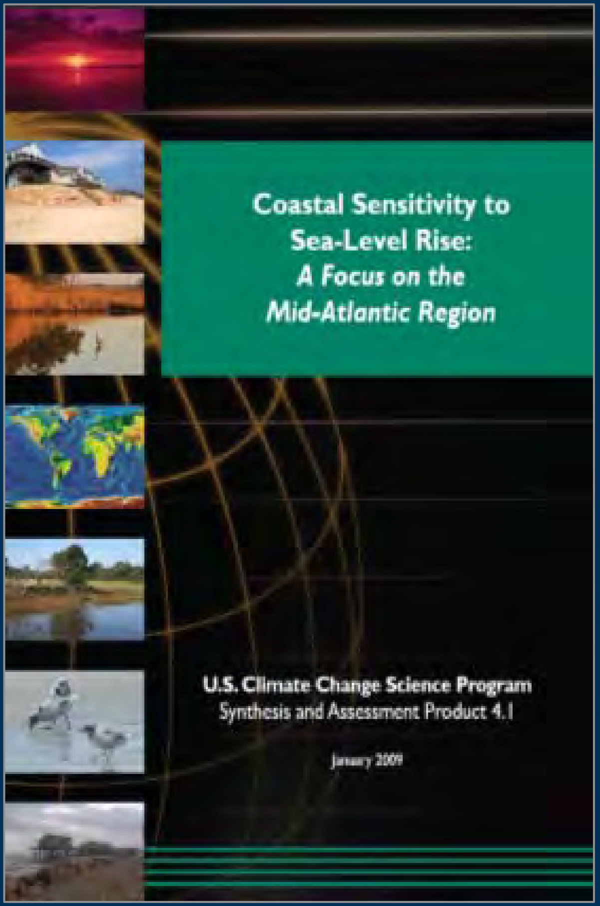


Infrastructure failure

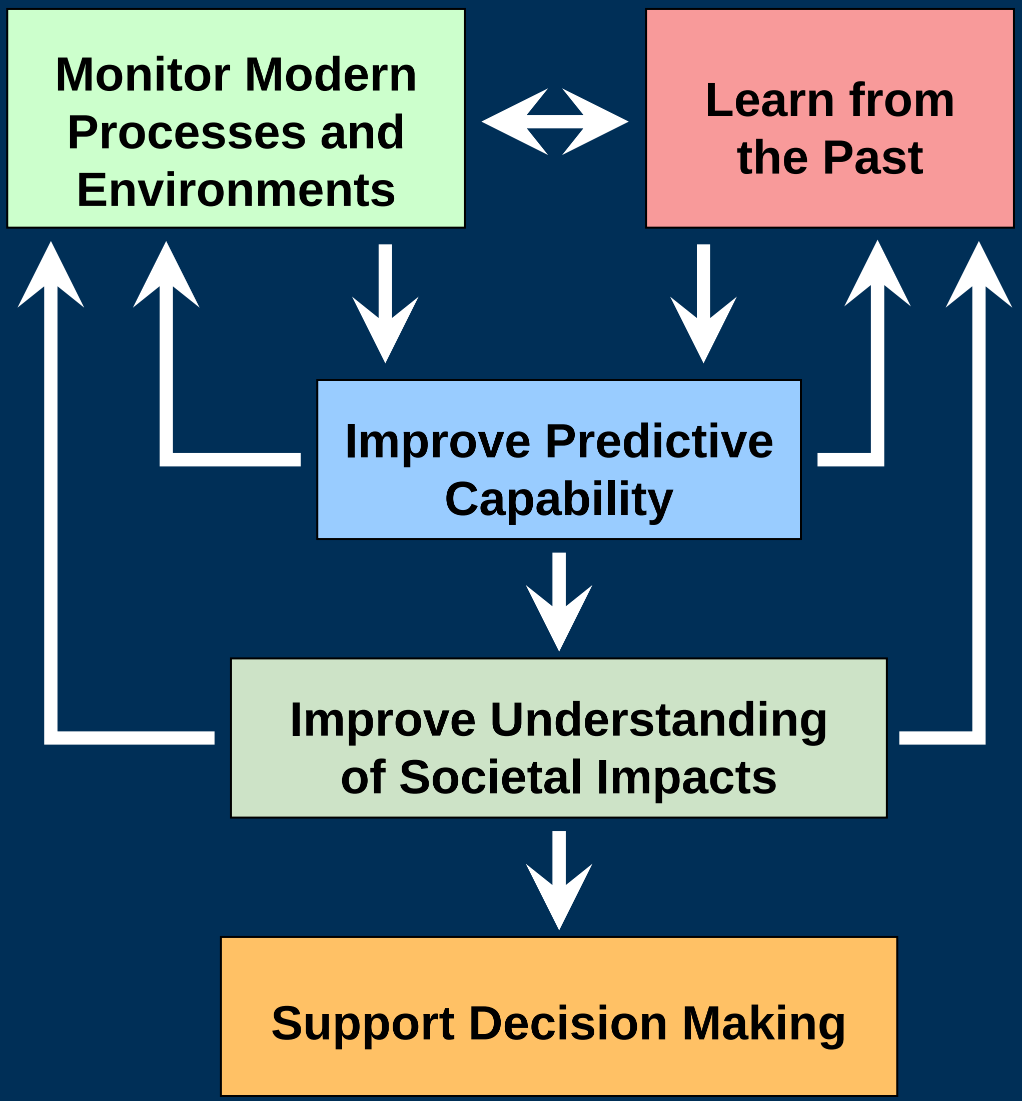
Ecosystem change

SAP 4.1 Societal Impacts and Implications

- Shore protection and retreat
- Population, land use, and infrastructure
- Public access
- Coastal flooding, floodplains and coastal zone management
- Feedback of actions on future decisions
- Ongoing adaptation
- Institutional barriers



Science strategy to address the challenge of climate change and sea-level rise



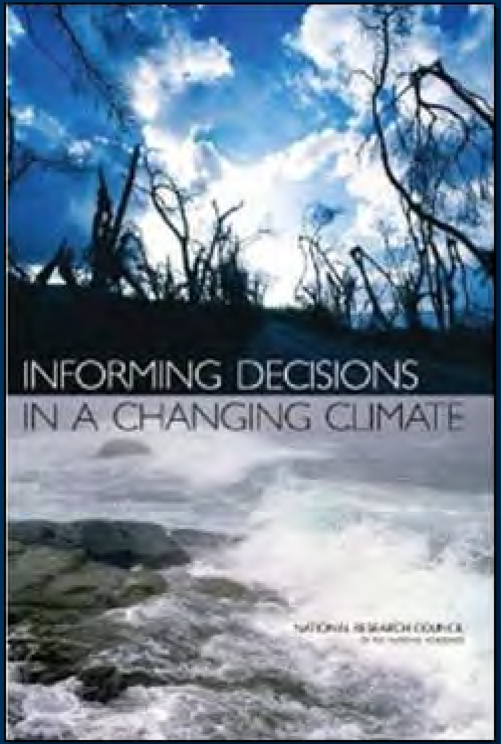
(Thieler et al., 2009)

Informing Decisions in a Changing Climate

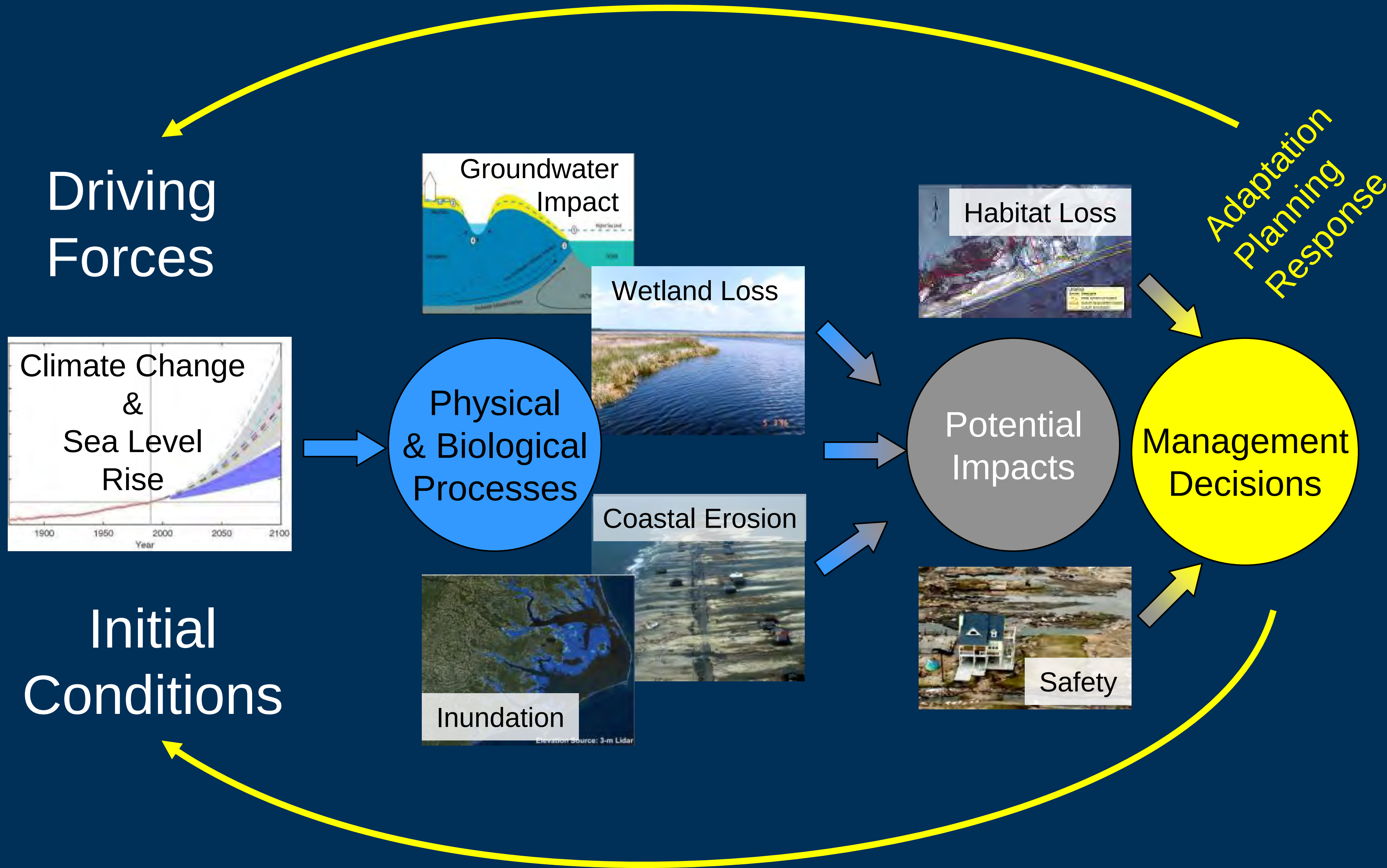
National Research Council (2009)

The end of “Climate Stationarity” requires that organizations and individuals alter their standard practices and decision routines to take climate change into account. Scientific priorities and practices need to change so that the scientific community can provide better support to decision makers in managing emerging climate risks.

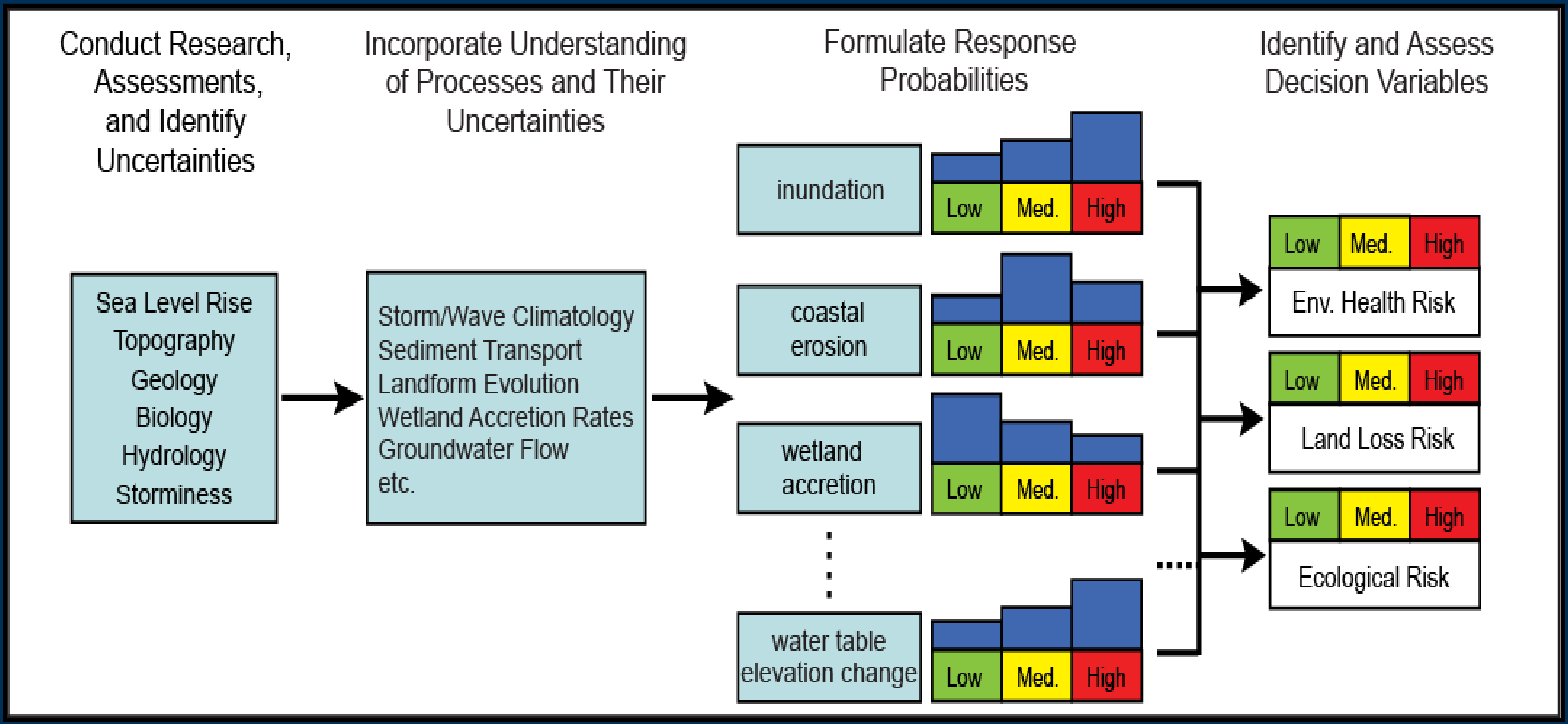
- Decision makers must expect to be surprised because of the nature of climate change and the incompleteness of scientific understanding of its consequences.
- An uncertainty management framework should be used because of the inadequacies of predictive capability.



Sea-level rise impacts: A multivariate problem with uncertainties everywhere



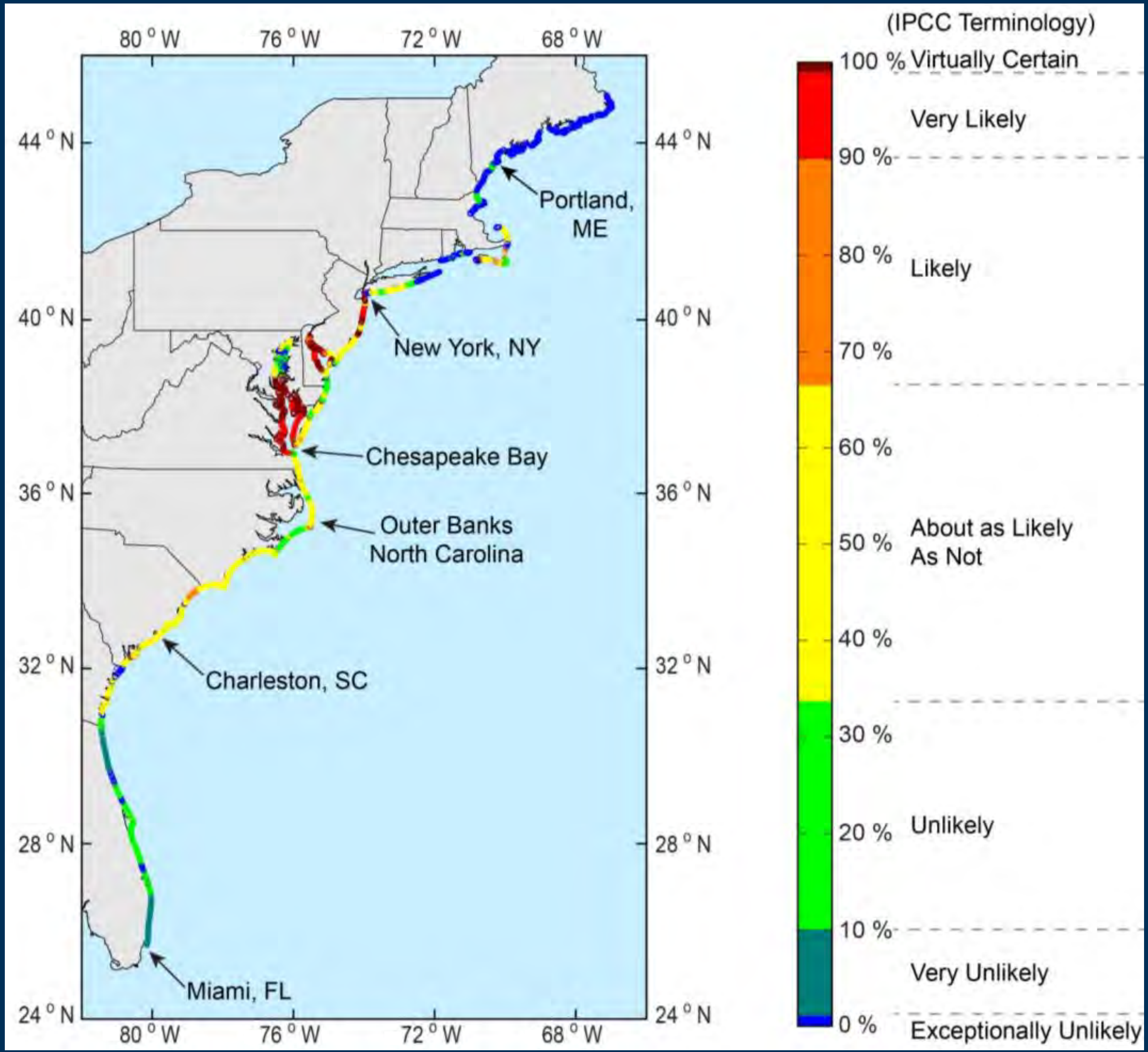
A conceptual approach to the multivariate, uncertainty problem



Explicitly include uncertainties, as well as management application

Mapping Erosion Risk Using Bayesian Networks

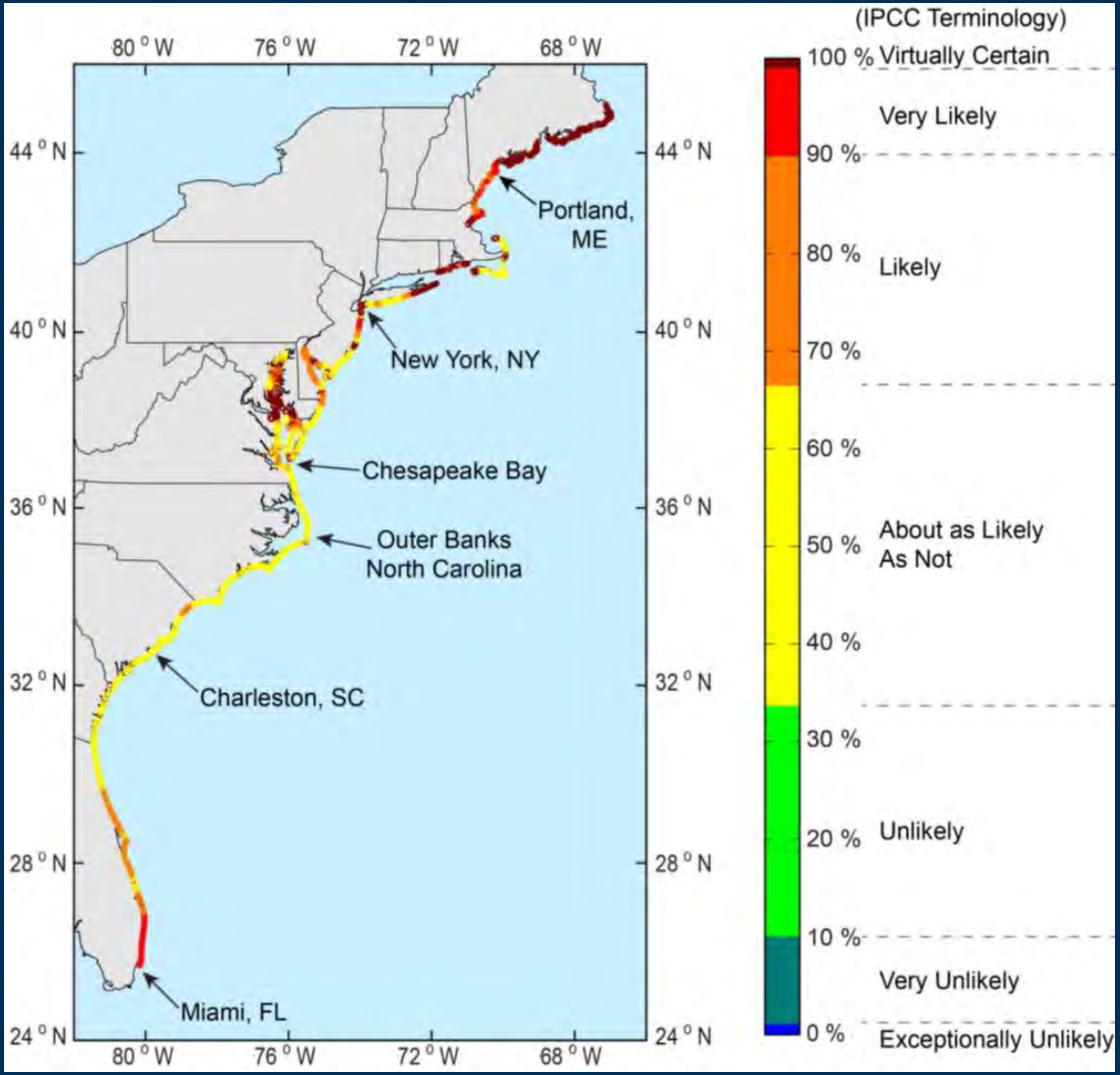
Probability of shoreline erosion >2 m/yr



Mapping Prediction Uncertainty

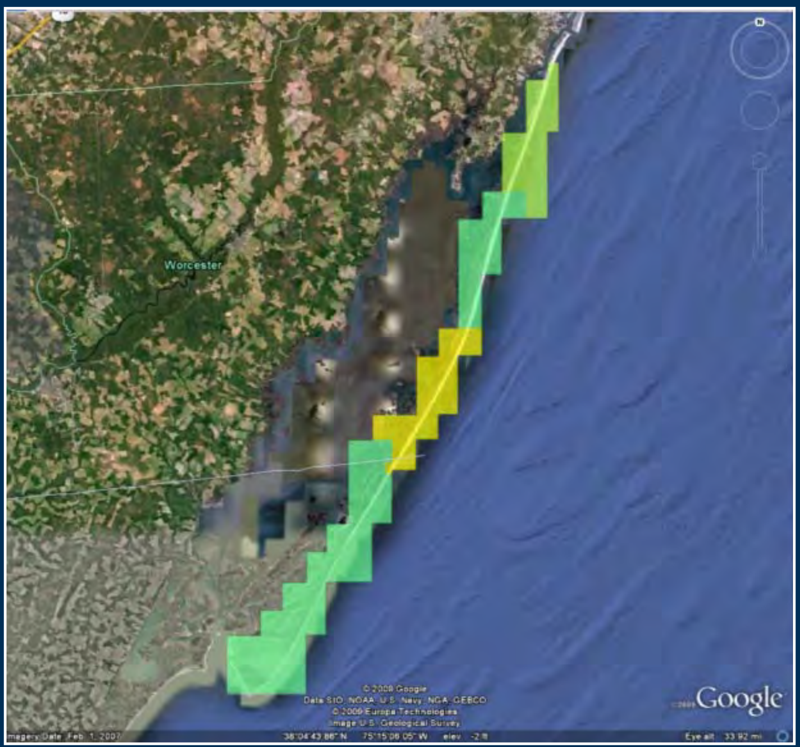
Higher probability = higher certainty of outcome

- Uncertainty map can be used to identify where better information is needed
- Areas of low confidence require
  - better input data
  - better understanding of processes
- Can use this map to focus research resources

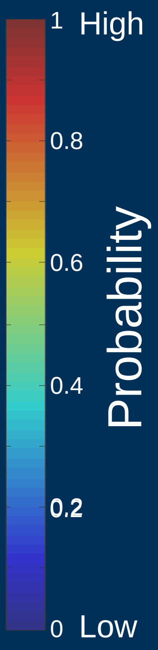


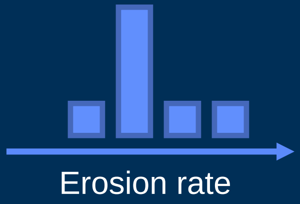
Application of a Bayesian network to an uncertain future: Probability of shoreline erosion >1 m/yr at Assateague Island National Seashore

Current conditions



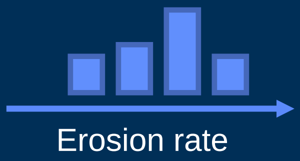
SLR +1 mm/yr, Wave ht. +10%





Narrow probability distributions

Relatively low uncertainty



Higher likelihood of erosion

Broader distributions

Increased uncertainty

Decision Support for DOI Agencies

Piping plover, *C. melodus*

- **Listed species**
- **DOI management responsibility**
- **Lifecycle includes substantial time on NPS lands for breeding, migrating, wintering**
- **Have interesting and specific habitat requirements that we can predict**
  - **Rangewide habitat availability**
  - **Attributes and distribution of breeding, foraging areas**
  - **Wave run-up and inundation sensitivity (morphologic and hydrodynamic detail)**
- **Can feed predictions back into population dynamics models**

Summary

- Future sea-level rise is problematic
  - It is a certain impact (we have already made a commitment to several centuries of SLR)
  - It is an uncertain impact (rates and magnitudes poorly constrained; human response unknown)

  - Effective climate change decision support will require changes in how we do science and how decision makers assimilate and use scientific information

- Probabilistic approaches have many applications
  - Convey what we know and what we know we don’t know
  - Synthesize data and models
  - Provide basis to focus research resources
  - Furnish information to support decision-making